THE ACTION OF SULPHUR-DIOXIDE ON PLANTS.

Untersuchungen üb. d. Einwirkung schwefliger Säure auf die Pflanzen. By Prof. Dr. A. Wieler. Pp. vii + 427. (Berlin : Gebr. Borntraeger, 1905.) Price 12 marks.

THIS work is a monograph dealing with the injurious action of sulphur-dioxide on plants, especially forest trees. The aspect in which the subject is regarded is primarily an economic one, although matters of purely physiological interest arise necessarily as offshoots of the main quest. The subject is an important one, since the destruction of trees owing to pollution of the air due to commercial undertakings is in places considerable. The author has written his book in a style such as he hopes may render it useful both to botanists and primarily to those technically and commercially interested in the subject.

The text is divided into eight chapters; of these the third occupies the greatest space, forming more than half the volume, and dealing with the experimental examination of the action of the gas on plants. The remaining chapters are devoted to its demonstration in leaves from affected areas, the proof that it enters through the stomata, its action on soil, the relation between height of trees and constitution of soil, the resistance of plants to the gas, the amount of it in the air of contaminated regions, and a final chapter on " Rauchexpertise." The results and conditions of the various experiments follow in tabulated form, then an appendix of ten pages by Oster. There are finally a few curves, and scattered throughout the book are a few rather poor prints from photographs.

Sulphur-dioxide was found in the leaves of all plants examined so far as eight kilometres from any known source of pollution; but no relation between degree of injury and concentration of the poison in the air was found, and no clear connection was detected between quantity of dioxide in leaves and distance of these from centres of contamination.

In agreement with F. Oliver, the author found that the gas penetrated into leaves solely through the stomata, a fact that had been disputed by v. Schroeder and Reuss.

The study, on a small scale, of the mode of action of the poison on plants forms the next step of the work. Throughout the volume the author distinguishes, as nearly every other observer had previously done, between acute and chronic affection of plants, the former being due to corrosive action of high percentages of dioxide within a short period, the latter to slow action of low percentages within a longer one. Prof. Wieler directed his attention almost entirely to the latter class of injury. Different plants and organs were found to react in very dissimilar manner, and to be unequally sensitive. The author points out that it is necessary to distinguish between sensitiveness of organs and resistance of plants as wholes. The re-

action advanced by R. Hartig as a specific one of leaves to the gas is shown to be valueless. A possibly specific reaction of angiospermous plants may be green coloration of injured cells of the mesophyll with methylene-blue. In the case of an unnamed variety of vine a specific reaction was found, namely, formation of a red pigment.

Normal respiration is held to be a periodic function. A distinctly adverse effect of the dioxide was found on photosynthesis, but no critical concentrations of affection could be established for different species. An inductive action of the poison was frequently noticed. The partial inhibition is shown to be due to direct action of the gas on the chloroplastids, not to closure of stomata. In addition to corrosions due to acute affection, the characteristic effects of a chronic nature observed in forests were obtained; these are precocious autumnal coloration and fall of leaves; similar effects resulted from partial starvation. The dioxide was found to inhibit metastasis of photosynthetic products, and to lessen the height of trees. No effect was exerted on transpiration.

The author proceeds to discuss the mode of action of the poison on plants. He believes that it unites with metabolites, especially aldehydes, and that sulphuric acid is liberated on consumption of these, injury being due to this acid; this hypothesis is held to explain the facts satisfactorily, especially those of induction.

The appearance and structure of chronically injured trees are next considered. The general features of such are strikingly similar to those due to defective nutrition, and could be satisfactorily explained on the supposition of direct action of the gas were it not that the concentration in the author's experiments was far higher than that of polluted areas. Hence Prof. Wieler attributes the effects to indirect action of dioxide on soil resulting in removal of basic constituents and consequent acidification due to humic acids. This view is amply discussed; it is pointed out that, correlated with this acidity, there will result change of the subterranean flora and of the physical constitution of soil, consequently also of the nutritive value of the latter. As a remedy for chronic injury, application of manures, especially basic ones such as lime, is recommended, the author being strongly of the opinion that the injury is almost entirely due to impoverishment of soil. Acute affection is to be considered as beyond control.

It is shown that no scale of resistance can be drawn for different species, since resistance of individuals varies with locality; the explanation of this is probably to be found in the natures of the particular soils and the special requirements of the plants, as suggested by Haselhoff and Lindau.

Concentration of sulphur-dioxide in the air of contaminated regions is shown to vary with direction of the wind, but no obvious relation with distance from the source of pollution was found, the content remaining approximately the same for different distances.

In conclusion, Prof. Wieler states that no simple and certain means of recognising injurious concentration has been found, except in the one case of the colour-reaction in an unnamed variety of vine; this he

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suggests might be used as an indicator. He repudiates determination of the dioxide in leaves as a test, and does not favour that of sulphuric acid; but he thinks that evaluation of the concentration of the gas in the air would be of some importance in determining the extent of its deleterious influence, the minimal lethal content being apparently somewhere near 1 :500,000. Injection of the intercellular spaces of leaves is a certain sign of injurious action of the gas, but not a specific one; this is also an induced effect.

Limitation of space forbids more than the shortest critique of this monograph. Its literary style and practical value would have been greatly enhanced had the author written it in a shorter manner; the wording is diffuse, and there is too much recapitulation. Prof. Wieler has, moreover, an unfortunate habit of interpolating the results of his experiments in the text, which consequently resembles a note-book in these parts; one result of this is intolerable weariness in the reader. The modes of application of many of the methods are susceptible of improvement, and conclusions are not infrequently drawn from results that are too ambiguous for the purpose.

But it is easy for a reviewer to be captious or hypercritical. The problems that Prof. Wieler has endeavoured to solve certainly involve considerable practical difficulties, and necessitate expenditure of much time and labour. His rehabilitation of an old hypothesis is ably done, and it is probable that subsequent work may confirm his results and conclusions, and raise the hypothesis to the rank of a theory.

F. ESCOMBE.

SOME SIDE ASPECTS OF MATHEMATICS.

L'Algèbre de la Logique. By Louis Couturat. *Scientia,* No. 24. Pp. 100. (Paris: Gauthier-Villars, 1905.)

A Geometrical Political Economy. By H. Cunynghame, C.B. Pp. 128. (Oxford: Clarendon Press, 1904.) Price 2s. 6d. net.

THERE are very few branches of study which cannot be made the subject of exact reasoning, and such reasoning can almost always be made, if not more exact, at least more simple and precise in its mode of expression by the adoption of mathematical language and the application of mathematical methods.

M. Couturat's work affords a general *exposé* of the symbolical analysis of logic founded by George Boole (1815-1864), and developed and perfected by Ernst Schröder (1841-1902) and other writers. It is an interesting study, not only to the logician, but also to the mathematician, who here is brought into contact with an algebra differing completely in its laws from the various algebras invented in connection with the study of directed and undirected magnitudes. Its symbols, in fact, do not denote magnitudes, but concepts or propositions. Its signs are based on those of algebra with the exception of the accent denoting negation, but the operations follow laws of their own. The discussion of these laws given in the present book is based on the works, not only of Boole and

Schröder, but also of Venn, Stanley Jevons, Poretsky, Macfarlane, Whitehead, Müller, Johnson, and Huntington. While the treatment appears suitable to a beginner, it must not be forgotten that in commencing the study of *any* algebra great difficulty is in general experienced in forming a tangible conception of the symbols involved. This criticism applies quite as much to ordinary algebra as to the subject-matter of the present work. Among all the algebras for beginners that have been written, we have not yet come across one which does exactly what is wanted, viz. base the subject on the *use of formulae* in numerical calculations relating to concrete quantities. On the other hand, readers of the present book are usually of maturer years, and may be better able to supply the illustrations for themselves.

In logic we have to deal with a discrete series of concepts or propositions, and it is natural that the language of algebra should be well suited to their treatment. The second book under review deals with quantities which are capable of continuous variations not necessarily expressible by any exact law, and for the study of these graphical methods are the most suited. Mr. Cunynghame's book does not require any knowledge of mathematics except such geometry as has been acquired at school, and very little of that. When we add that this particular knowledge mainly consists in the capacity to represent on squared paper the fluctuations in the price of wheat, the national debt, or the income tax, and that special stress is laid on this capacity in modern school examinations, it will be seen that the present is a very favourable time for introducing a book of the kind. We may not live to see the time when electioneering addresses take the form of mathematical lectures illustrated by diagrams, but we may be certain that, if any nation ever rises to this state of intelligence—and at the present time Germany is the most promising—that nation will outstrip all others in efficiency and prosperity. It is only by methods such as those here described that fiscal questions can be studied, and it is much to be hoped that the present book will teach a *few* English people how misleading it is to rush to conclusions based on *isolated* statistics, which can be turned about in such a way as to prove anything.

The method of this book was introduced into England by Prof. Marshall, Fleming Jenkin, and Stanley Jevons, and the author is also indebted to Prof. Foxwell for much information. The subjects treated include supply and demand, surplus value, taxation, monopoly, international trade, and Marshall's curves.

Mathematical teachers may well reflect on Mr. Cunynghame's reason for avoiding the words "graph" or "graphical." According to his interpretation, a "graph" is to be regarded as "a curve which merely aims at presenting a collection of facts to the eye without any known law behind it. . . ." "When, however, a law can be discovered governing the form of the graph it ceases to be a mere graph and becomes promoted to the dignity of a curve." And yet "graphs" were introduced into elementary mathematical syllabuses with a great flourish of trumpets not so very long ago, and were